An introduction to antenna noise cancellers

Most amateurs who have been licensed for several decades or more will no doubt have fond memories of bands free from the electronic and electrical noise that now plague the spectrum.

Few amateurs these days are lucky enough to live in a low-noise environment, and most of us will, at some stage, have to deal with locally-generated noise from various sources such as switch-mode power supplies, computer equipment etc.

Introduction

In general, the HF bands are more prone to interference, although many of us have experienced problems on bands up to 1240MHz (23cm) and higher. In the first instance, it is necessary to determine if the interference is being generated in-house as this will, in almost all cases, be easiest to remove or mitigate [1]. Noise sources that emanate from places other than in your own property will clearly need to be identified and tracked to source, which may involve use of a portable spectrum analyser or SDR receiver for nearby devices, or some direction-finding skills for more distant noise sources. An excellent article by Ian, G0CNN, is well worth a read [2].

Often it is not possible to mitigate, or remove, the noise generated by noise sources, perhaps because of uncooperative neighbours. In the case of a 'stealth' amateur radio station, it may not be desirable to approach neighbours at all. Whilst an IF or AF DSP in a modern radio, in conjunction with front-end attenuation and noise blanking, can often provide some reduction in received noise, the most effective way to reduce noise is, of course, to prevent it getting into your receiver in the first place. A very effective way of attenuating or removing noise via the antenna is by use of a noise-cancellation device, often referred to as an 'antenna noise canceller'. This short article will cover the use of such devices, showing what can be achieved by their use and their limitations.

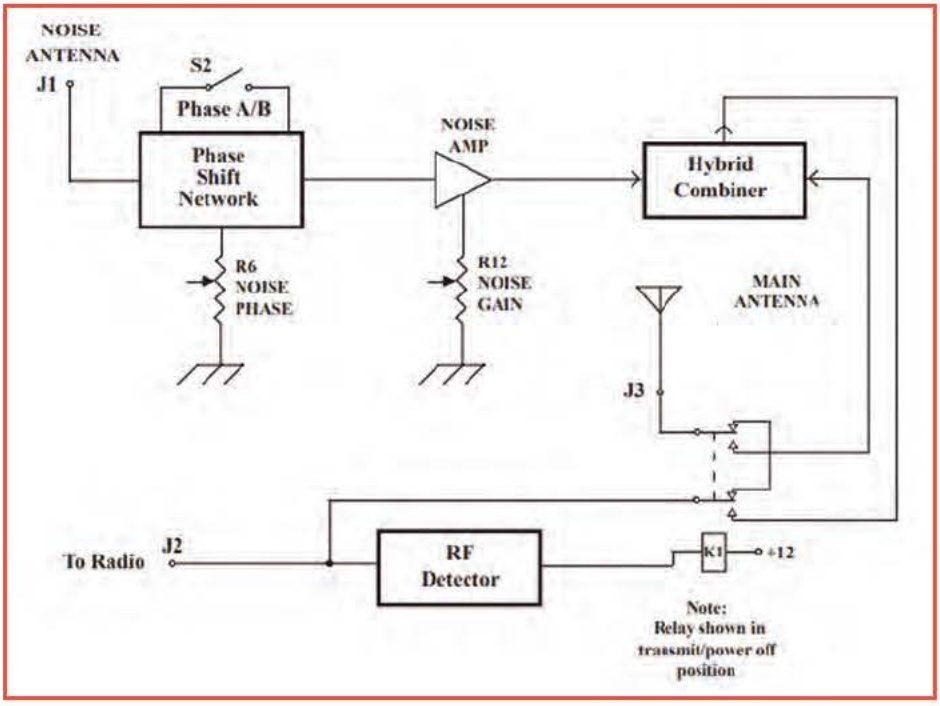

FIGURE 1: A block diagram of the Timewave ANC4 antenna noise canceller.

Principle operation of the antenna noise canceller

The operation of an antenna noise canceller is straightforward, and is based on the principle that two waveforms of the same shape and amplitude, but 180° out of phase with each other, cancel when added together, known in Physics as 'destructive interference' [3]. An antenna noise canceller has two antenna inputs, one for the main station antenna used for receiving, and one for another receive-only antenna referred to as the 'noise antenna'. The main station antenna receives both the wanted signal and the locally-generated noise. The noise antenna picks up the locally-generated noise and, in general, will be shorter and less effective on the band in use so that the wanted signal is completely absent or very much weaker than the locally-generated noise. The signal from the noise antenna is passed through a phase-shift network so that the noise can be made to be 180° out of phase with the noise on the main antenna. The phase-shifted noise signal is then amplified so that it is at same strength as that picked up by the main antenna, and is combined with the signal from the main antenna, thus cancelling the noise and leaving only the wanted signal. Figure 1 shows the block diagram of a commercially-available antenna noise canceller, the Timewave JPS ANC-4 [4]. There are other units available such as the MFJ 1026 [5], and some of Chinese origin such as the X-phase [6]. It is of course possible to build your own antenna noise canceller, and there are numerous designs to be found on the internet [7].

The commercially-available units are usually designed to operate on HF and 50MHz only. Keying on transmit is achieved by either RF VOX, or PTT line input. When not switched on, most commercially-available units default to by-pass mode. Linear amplifiers, or any meters such as VSWR meters etc, should be placed after the noise canceller.

FIGURE 2: The ANC4 noise canceller in use (the screw-in telescopic whip is shown at the top far left).

The noise antenna

The noise antenna in an antenna noise canceller system is perhaps the most critical part of the system and will determine the effectiveness of noise cancellation. The noise antenna needs to be able to pick up enough of the local noise to be cancelled, whilst at the same time receive a much-lower level of the wanted signal (preferably zero). As such, the noise antenna is usually deliberately made to be shorter than a main antenna for the band in use. Both the Timewave and MFJ cancellers come with a short telescopic antenna that may be screwed into the top of the unit (**Figure 2**). In general, use of such a telescopic antenna will only be effective for noise sources close by (up to 5m), such as might be emanating from a neighbouring property. For noise sources that are further away, an external antenna is usually necessary, and this can take the form of a very short dipole, small loop, or a vertical antenna. The noise antenna should be placed as near as possible to the local noise source, and preferably close to ground level to attenuate any distant signals. For example, at my last QTH, my neighbour had a cooker, the electronic clock/timer of which generated a noise of around S5 on most of the HF bands, which they were unwilling to switch off when not in use. I used a short, untuned, horizontal, balanced dipole of total length around 1.2m. This dipole was placed in a ground-floor room next to an external wall and alley, so that the noise antenna was approximately 4.5m away from the cooker. Using this antenna, I was able to eliminate the noise on all bands from 160 to 10 metres. Some degree of patience and experimentation is usually required to determine the optimal position (including the polarisation) for placement of a noise antenna. Occasionally, not enough noise is picked up by a small noise antenna, and it may be necessary to increase the size, hence possibly increasing the level of the wanted signal picked up by the noise antenna which may interact with it.

Types of noise that can be cancelled

Antenna noise cancellers can eliminate or attenuate a wide range of noises, including power-line noise emanating from a single point (see (e) below), wideband hash-type noise, and carrier signals (eg so-called 'birdies'). The interfering waveform needs be continuous and reasonably stable in its shape

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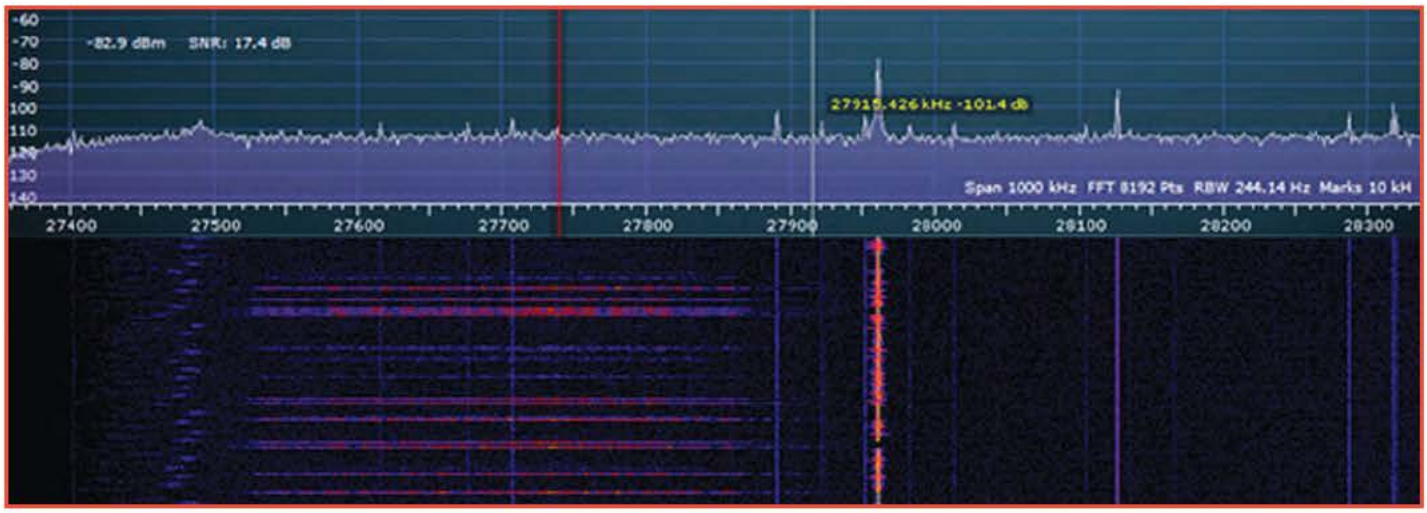

FIGURE 3: Interference below, and in, the 10m band at G0FVI.

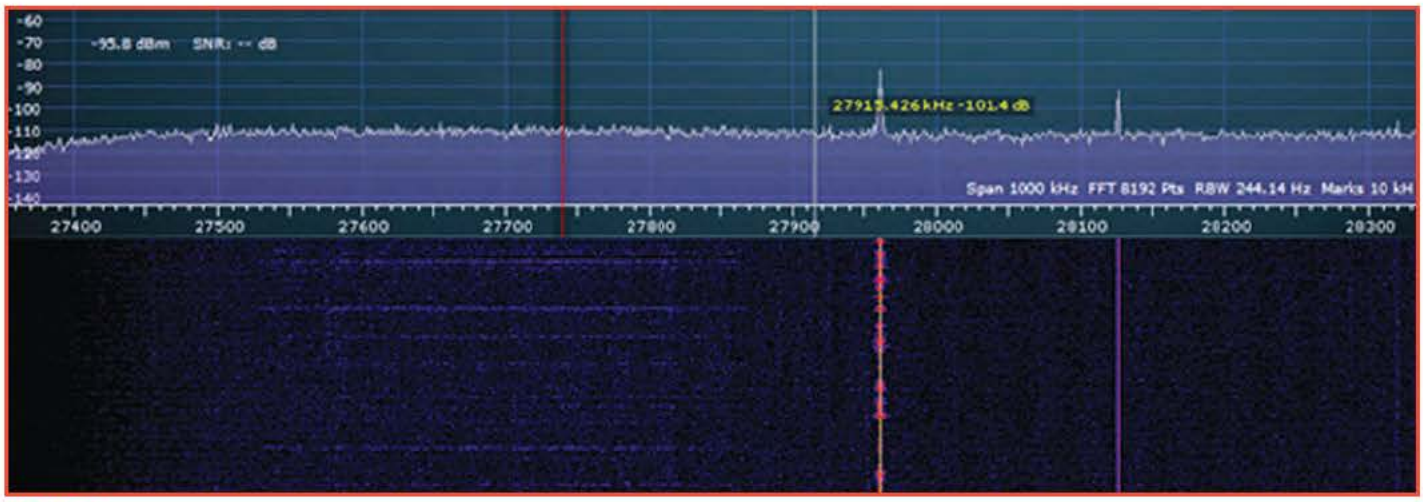

FIGURE 4: The 10m band after removal of a local interfering noise source.

and amplitude for effective cancellation. Unstable (drifting) noises can be eliminated, but will almost certainly require continuous adjustment of the phase and or amplitude controls of the noise canceller which in practice is difficult to achieve.

Disadvantages of antenna noise cancellers

Whilst antenna noise cancellers can be most effective in removing or reducing noise, there are some caveats to their use listed here:

(a) Adjustment of phase and amplitude controls on these units requires of patience, and the user will almost certainly find that very small adjustments of the controls will be needed to find the required null at which noise is removed or attenuated to an acceptable level.

(b) Some attenuation of the wanted signal may occur when using a noise canceller. The insertion loss of my Timewave unit is around 6dB.

(c) Correct placement of the noise antenna is critical, and on occasions the noise antenna may not be able to receive enough of the noise signal for effective cancellation.

(d) Antenna noise cancellers are usually only able to remove one source of noise at a time. The signals from different noise sources will rarely be of the same phase so, if you have multiple interfering signals, it may be a case of choosing which one to remove.

(e) A noise source that emanates from several different directions (and thus phase) will almost certainly not be removed by an antenna noise canceller, the classic example being power-line noise.

In practice – an example

There are numerous examples on YouTube of some quite-dramatic noise removal (enter ANC4 or MFJ 1026 into the search bar of YouTube) which can give you some idea as to the effectiveness of these units. Presented here is an example of some noise removal at G0FVI. One of the neighbouring properties appears to be using some kind of power-line data device which uses multiple band segments within the shortwave bands. These devices use the home electrical wiring to distribute internet signals to other parts of a property where WIFI is weaker. The particular device in question appears to be notched for the amateur HF bands, although there remain some rather tiresome low-level carriers and a slightly raised noise floor, most notably on the 10m band, with what appears to be very strong data bursts which wipe out completely most the old CB 27/81 band below 10m (**Figure 3**). Note there is a carrier at 28.125MHz emanating from the home alarm system at G0FVI, the other carriers shown in Figure 3 are 'birdies' from the interfering PLT device. A carrier can also be seen around 27.915MHz from a QSO of some local CB users. Using the in-built telescopic whip for my ANC4, it was possible to remove the interfering data bursts and associated 'birdies' almost completely (see **Figure 4**). Note that the carrier from my home alarm system is still present at 28.125MHz, and is not removed as it is of a different amplitude and phase from the interfering data device. The QSO taking place around 27.915MHz has also not been removed, so this must represent a wanted signal (unfortunately 10m was not open at the time the screenshots were taken!). There is, of course, some reduction in noise level and attenuation of signals arising from the insertion loss of the noise canceller itself.

Note that the noise source given in this example has multiple points of radiation (RF through house wiring), which as mentioned above can often not be removed completely using an antenna noise canceller.

Will it work for me?

If you have some stubborn interference that you've been unable to remove, you may already be thinking about using an antenna noise canceller. Whilst many radio amateurs have found that antenna noise cancellers have allowed them to continue with their hobby, some will no doubt have experienced less satisfying results. The effectiveness of an antenna noise canceller will (as outlined above) depend very much on the proximity of the noise source and effectiveness of your noise antenna, and so it is advisable to spend some time looking for the source of any noise before buying such a device. For locally-generated noise, say within a 100m or so, you will probably find (as I have) that an antenna noise canceller can be a useful device, although you will need patience and will almost certainly have to experiment with different configurations of the noise antenna. You may need to use a longer noise antenna, which may possibly attenuate the wanted signal somewhat if the phases of the wanted and unwanted signals match, although this may not necessarily be a bad compromise as it may make the difference between having a QSO or not!

References

[1]https://rsgb.org/main/technical/emc/experiencing-emc-interference/
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